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UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN FRANCISCO DIVISION

WAYMO LLC, Plaintiff, v. UBER TECHNOLOGIES, INC., OTTOMOTTO LLC; OTTO TRUCKING LLC, Defendants.	Case No. 3:17-cv-00939-WHA **SUPPLEMENTAL DECLARATION OF JAMES HASLIM IN SUPPORT OF DEFENDANTS' SUR-REPLY TO PLAINTIFF WAYMO LLC'S MOTION FOR PRELIMINARY INJUNCTION** Date: May 3, 2017 Time: 7:30 a.m. Ctrm: 8, 19th Floor Judge: The Honorable William Alsup Trial Date: October 2, 2017

<u>REDACTED VERSION OF DOCUMENT SUBMITTED UNDER SEAL</u>

I, James Haslim, declare as follows:

1. I am a Senior Manager, Engineering for the Advanced Technologies Group at Uber Technologies, Inc. ("Uber") as of January 2017. I understand that Waymo has filed a lawsuit against Uber, Ottomotto LLC ("Otto") and Otto Trucking LLC in the U.S. District Court for the Northern District of California. I submit this supplemental declaration in support of Defendants' Sur-Reply to Waymo LLC's ("Waymo") Motion for Preliminary Injunction. I have personal knowledge of the facts set forth in this declaration and, if called to testify as a witness, could and would do so competently.

The Spider Project

2. As stated in my original declaration, I joined Otto in May 2016 as Senior Mechanical Engineer and LiDAR lead, after Otto completed its acquisition of Tyto LIDAR LLC ("Tyto"). I was tasked with leading the team at Otto in developing a light detecting and ranging (LiDAR) solution for autonomous trucks. Shortly after I joined Otto, my team began working on a fiber-based LiDAR project intended for autonomous trucks. This project was known as the "Spider" project. The Spider project sought to leverage a pre-existing LiDAR sensor (known as "Owl") that had been developed at Tyto beginning in 2012. Tyto's Owl device was a mapping LiDAR sensor that used a single fiber laser. The Spider project was never completed and my team abandoned the Spider project to work on a very different LiDAR design (called "Fuji") in late October 2016. Prior to abandoning the Spider project, we built a few components for testing purposes, but we never completely assembled these parts, and we never built all of the components needed for functional prototype, much less a complete LiDAR device. Thus, Spider was never made, used, sold, offered for sale, or imported, and there are no plans to revive the abandoned Spider project.

3. The design concept for the Spider project was a LiDAR sensor with eight optical cavities, eight fiber lasers having a wavelength of approximately 1550 nanometers, and sixteen optical lenses (with each optical cavity having two optical lenses). The Spider design was intended to emit 3.2 million points or beams per second. Figure 1A and 1B, below, are true and

correct computer aided design (CAD) drawings of the Spider design. Figure 1A shows a perspective view of the design, and Figure 1B shows a top view of the design:

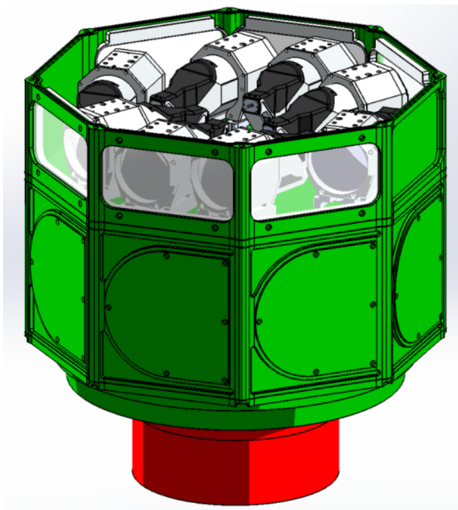

Figure 1.A

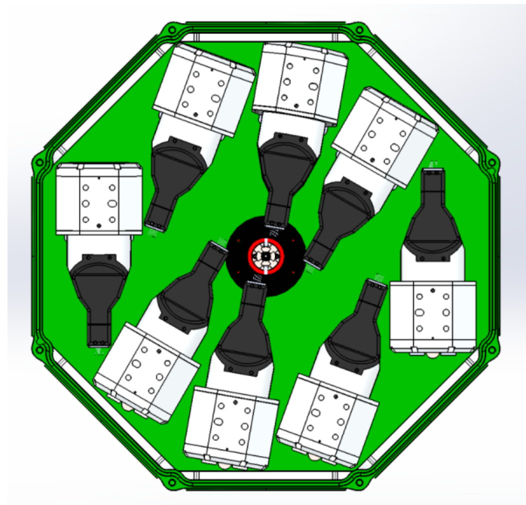

Figure 1.B

4. After Uber acquired Otto in August 2016, I continued to lead my team's efforts on the Spider project until we pivoted to the Fuji project in late October 2016. Although Spider was intended to have eight optical cavities, our team only built a single optical cavity for testing purposes before the Spider project was abandoned. Figure 2.A, below is a true and correct photo of the test Spider optical cavity. Figure 2.B, below, is a true and correct annotated CAD drawing of a cross-sectional side view of an optical cavity design for Spider.

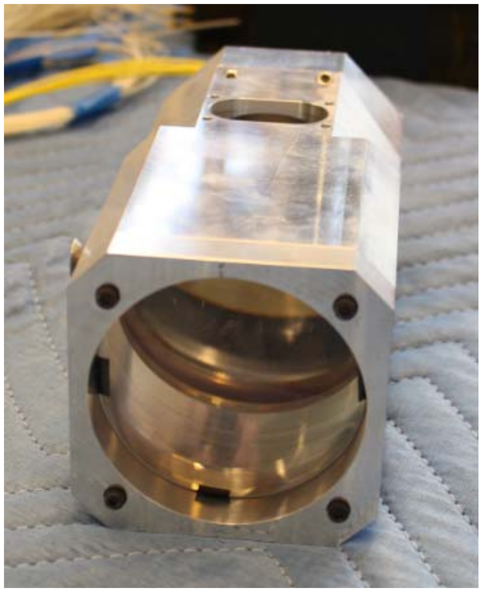

Figure 2.A

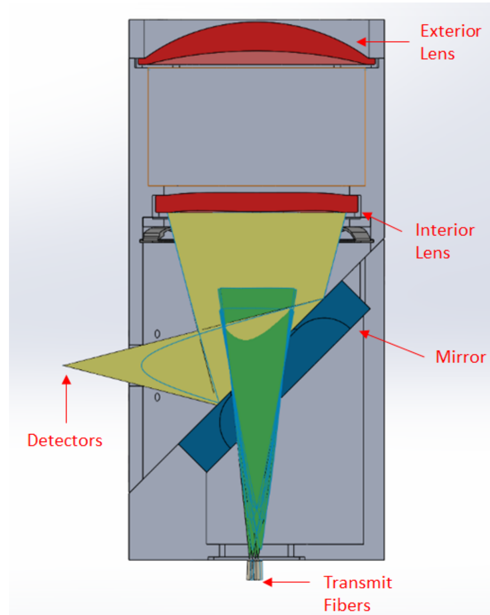

Figure 2.B

5. The Spider design included eight fiber lasers, each of which was split into eight "transmit fibers" to create a total of 64 transmit channels. Each cavity had eight transmit fibers—a single transmit fiber from each of the eight fiber lasers. Spider did not use any printed circuit boards (PCB) for positioning transmit fibers within a cavity. Rather, the transmit fibers were mounted into ceramic sleeves or ferrules which were bonded into holes drilled through a metal plate. Each cavity also had a flat mirror with a large hole to allow the light emitted from the transmit fibers to travel straight through the hole in the mirror, through two separate collimating lenses (an interior lens and an exterior lens) and into the environment.

6. Each optical cavity had two optical lenses. Figures 3.A and 3.B show true and correct schematics of the two optical lenses for each Spider cavity. Figure 3.A shows the schematic of the interior lens, i.e., the lens closest to the transmit fibers, and Figure 3.B shows the schematic of the exterior lens, i.e., farthest from the transmit fibers. The two lenses work together to provide collimation of the light emitted from the transmit fibers into the environment and to focus the target-reflected light to the detectors.

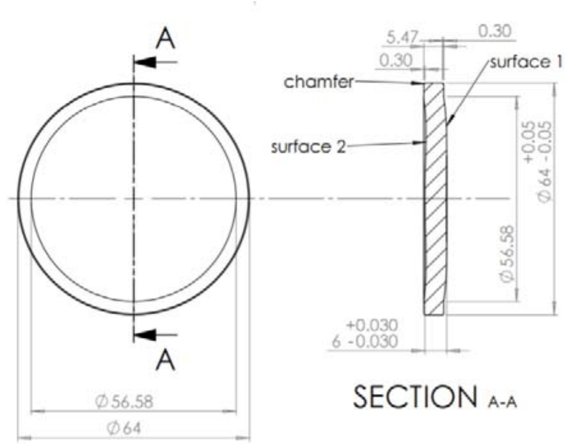

Figure 3.A

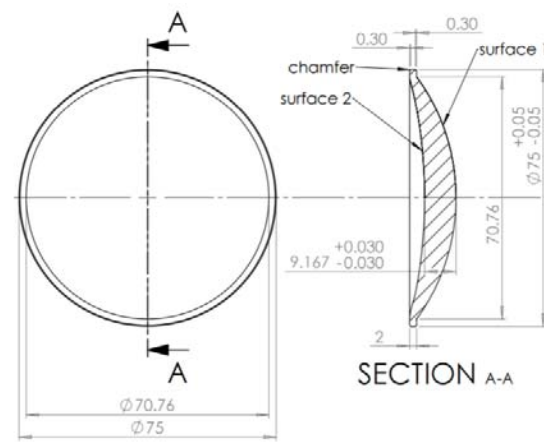

Figure 3.B

7. The eight fiber lasers in the Spider design were fiber MOPA lasers. MOPA stands for master oscillator power amplifier and refers to a configuration consisting of a master laser (also known as a seed laser) that generates a low power version of the desired pulse signal and an optical amplifier to boost the output power of this pulse signal. A fiber MOPA laser refers to a MOPA laser that uses a fiber amplifier. The Spider design included [redacted] for its fiber lasers to obtain the power levels necessary for use as emitters in a LiDAR sensor. This is a well-known technique to amplify the output power of a fiber laser.[1] The Spider design included [redacted], which is a commercially available fiber purchased from iXBlue.[2] Figure 4 below is a screenshot of iXBlue's website,

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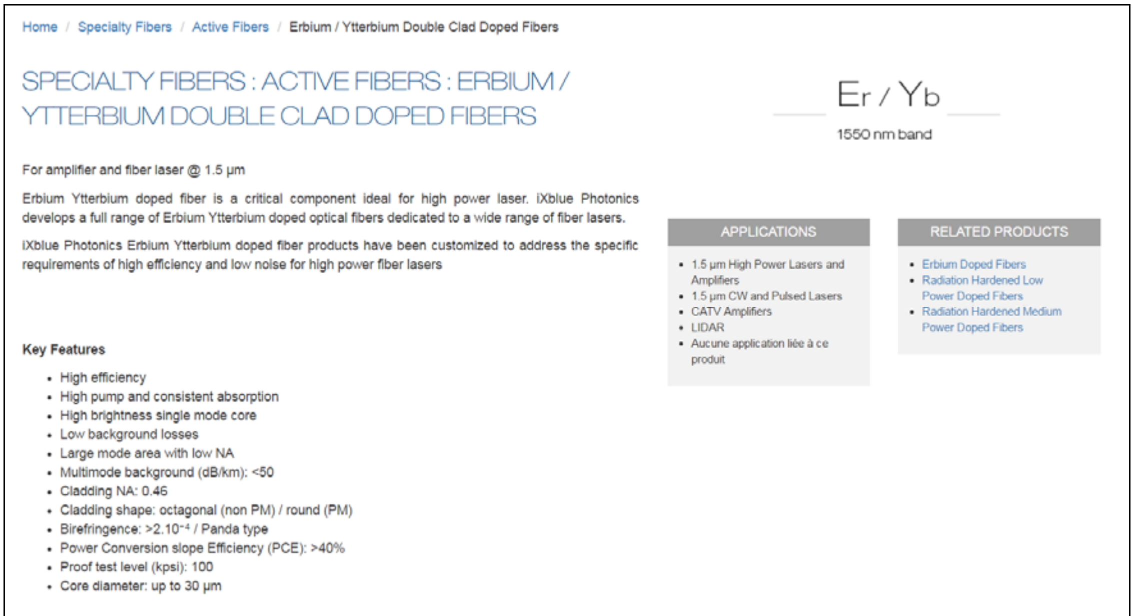
[1] *See*, *e.g.,* RP Photonics, *Fiber Amplifiers*, https://www.rp-photonics.com/tutorial_fiber_amplifiers10.html; Grzegorz Sobon et al., *Controlling the 1 μm spontaneous emission in Er/Yb co-doped fiber amplifiers*, 19 Optics Express 19106 (2011), *available athttps://www.osapublishing.org/DirectPDFAccess/FBA42477-936E-A370-B8E0FD26AF56013C_222547/oe-19-20-19104.pdf?da=1&id=222547&seq=0&mobile=no* ; Clémence Jollivet et al., *Specialty Fiber: Multiple Applications Benefit from Advances in High-Performance Er:Yb Co-Doped Double-Clad Fiber*, Laser Focus World (Sept. 14, 2016), http://www.laserfocusworld.com/articles/print/volume-52/issue-09/features/specialty-fiber-multiple-applications-benefit-from-advances-in-high-performance-er-yb-co-doped-double-clad-fiber.html.

[2] *See, e.g.*, iXBlue, *Specialty Fibers: Active Fibers: Erbium / Ytterbium Double Clad Doped Fibers*, https://photonics.ixblue.com/products-list-detail/erbium-ytterbium-double-clad-doped-fibers; Newport, *Erbium & Ytterbium Co-Doped Fibers*, https://www.newport.com/f/erbium-&-ytterbium-doped-fibers; Fibercore, *Erbium Doped Fiber IsoGain™*, http://fibercore.com/product/erbium-doped-fiber-isogain.

which discloses that its Erbium Ytterbium double clad doped fiber is an ideal component for a "high power laser" (i.e., "1550 nm band") and lists "LIDAR" as an intended application for this fiber.



Home / Specialty Fibers / Active Fibers / Erbium / Ytterbium Double Clad Doped Fibers

SPECIALTY FIBERS : ACTIVE FIBERS : ERBIUM / YTTERBIUM DOUBLE CLAD DOPED FIBERS

Er / Yb

1550 nm band

For amplifier and fiber laser @ 1.5 µm

Erbium Ytterbium doped fiber is a critical component ideal for high power laser. iXblue Photonics develops a full range of Erbium Ytterbium doped optical fibers dedicated to a wide range of fiber lasers.

iXblue Photonics Erbium Ytterbium doped fiber products have been customized to address the specific requirements of high efficiency and low noise for high power fiber lasers

APPLICATIONS

- 1.5 µm High Power Lasers and Amplifiers
- 1.5 µm CW and Pulsed Lasers
- CATV Amplifiers
- LIDAR
- Aucune application liée à ce produit

RELATED PRODUCTS

- Erbium Doped Fibers
- Radiation Hardened Low Power Doped Fibers
- Radiation Hardened Medium Power Doped Fibers

Key Features

- High efficiency
- High pump and consistent absorption
- High brightness single mode core
- Low background losses
- Large mode area with low NA
- Multimode background (dB/km): <50
- Cladding NA: 0.46
- Cladding shape: octagonal (non PM) / round (PM)
- Birefringence: $>2.10^{-4}$ / Panda type
- Power Conversion slope Efficiency (PCE): >40%
- Proof test level (kpsi): 100
- Core diameter: up to 30 µm

Figure 4

8. As mentioned above, we abandoned the Spider project before we completed a prototype device. Spider was designed to have eight optical cavities, but we had only built one optical cavity for testing purposes, and never mounted that single test optical cavity onto the rotating base. For the one test optical cavity that we built, we were unable to place the transmit fibers accurately enough to align the eight transmit fibers to the eight photodetectors.

9. My team worked on the Spider project until late October 2016. Spider proved to be undesirable and was abandoned because of the complexities of the design, the anticipated difficulty of scaling the manufacturing of the design, and its large size, heavy weight, and high power requirement. As designed, Spider would likely have weighed approximately 165 pounds, which would have been about six times heavier than a Velodyne HDL-64. While the large size and heavy weight of the Spider design was less of a consideration for a semi-truck, the weight of Spider design, along with the additional components that would have been required to mount a

completed Spider onto the roof of a passenger vehicle, would have likely exceeded the rated payload of the roof of a Volvo XC90 (220 pounds).

10. The LiDAR team's decision to abandon Spider and pivot to Fuji was made by the engineering team and was based on design considerations. When I met Scott Boehmke and Eric Meyhofer in October 2016 to discuss my team's work on Spider, we concluded that the Spider design would be undesirable for use in Uber's vehicles because of the reasons explained above (i.e., the complexity of the design, anticipated difficulty with scaling, and its large size, heavy weight, and high power requirement). Anthony Levandowski did not direct the LiDAR team to pivot from Spider to Fuji, but instead deferred to the engineers on the LiDAR team's recommendation and judgment to pursue a bistatic, diode-based LiDAR design. Exhibit A, attached hereto, is an email exchange between Eric Meyhofer, Scott Boehmke, Dan Gruver, and me regarding the feasibility of pivoting from [redacted] (i.e., Spider) to [redacted] (i.e., a new diode-based design, which became Fuji).[3] In this email, Eric Meyhofer stated that he had spoken with Anthony and had promised Anthony that the team would [redacted] As I had explained during my deposition, I did not even know if Anthony was aware that Eric, Scott and I had already committed to pivoting from Spider to Fuji when I announced the pivot to the rest of the LiDAR team on October 28, 2016 in San Francisco.[4] The LiDAR team's decision to abandon the Spider project to work on Fuji was based on the aforementioned design considerations and was not at the instructions of Uber's legal team or due to any legal issues.

The Fuji Device

11. As I explained in my earlier declaration, Fuji is a LiDAR sensor having two optical cavities each with 32 channels oriented at different vertical angles to capture the field of view necessary for applications in self-driving cars. Specifically, Fuji has a total vertical field of

[3] A true and correct copy of this document was provided to Waymo as UBER00008592 and was introduced and designated by Waymo as Exhibit 62 in my April 18, 2017 deposition in this case.

[4] *See* Haslim Dep. 88:6-21, April 18, 2017. A true and correct excerpt of this section of my deposition is attached as Exhibit B to this declaration.

view of 30.23 degrees, from -22.0 degrees to 8.23 degrees. Each cavity has a separate transmit lens and receive lens. The transmit lens has a focal length of 150 mm. Figures 5.A and 5.B, below, are a true and correct photos of Fuji as of March 2017. As Figures 5.A and 5.B show, the two optical cavities are mounted on a rotating base that spins the optical cavities to capture a 360 degree horizontal field of view. The rotating base includes a stationary portion that will couple to the roof of a vehicle. As I had also stated in my earlier declaration, no Fuji device has ever been mounted on any vehicle for testing. Above the optical cavities is the timing board, which measures the time between transmitted pulses and received target-reflected pulses. The yellow cable in the Figures 5.A. and 5.B is a commercially available [redacted].[5]

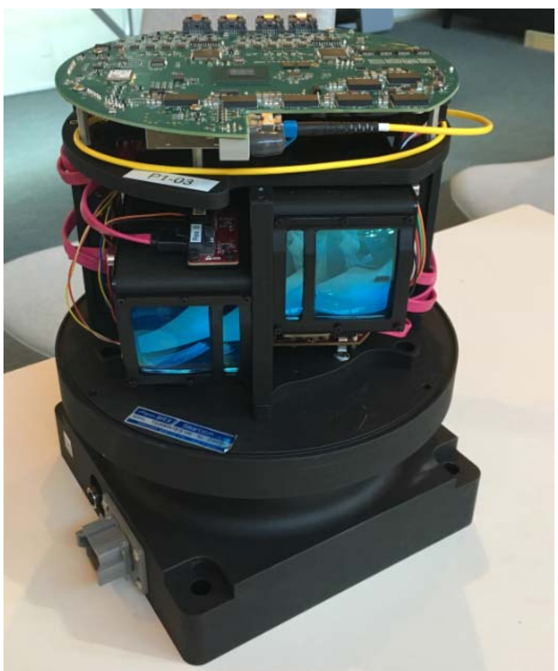


Figure 5.A

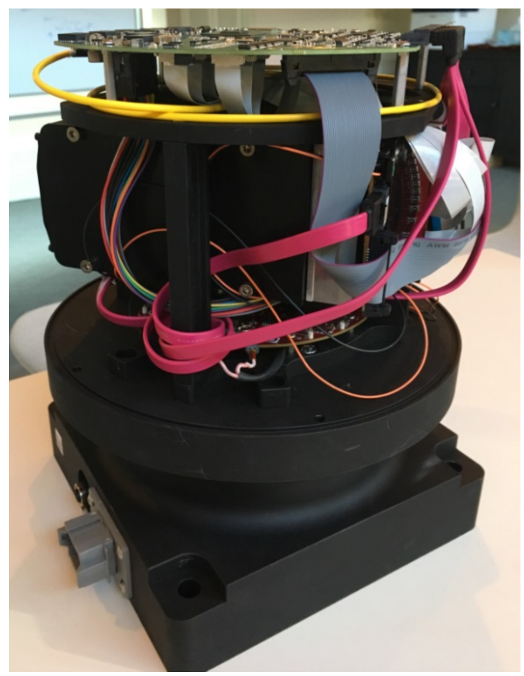


Figure 5.B

12. There are [redacted] transmit printed circuit boards (PCBs) within each cavity in Fuji. Each channel represents light from a single laser diode, and the 32 laser diodes are distributed over [redacted]. As I had explained in my prior declaration, I came up with the idea of

[5] *See, e.g.*, Princetel, *FORJ: Miniature fiber rotary joints (MicroJx Series)*, http://princetel.com/forj_mjx.asp.

distributing the 32 laser diodes across [redacted] through an iterative approach. I initially wanted to fit all 32 laser diodes on a single PCB because that would simplify the process of aligning the laser diodes to the detectors. As stated in my October 28, 2016 email to Scott Boehmke, however, I realized that having two cavities and mounting 32 laser diodes on a single PCB per cavity did not provide enough spacing between the laser diodes' circuits and associated components and had suggested to Scott that we would need to [redacted] for each of the two cavities.[6]

13. I understand that in its reply brief, Waymo contends that there is no other evidence of Uber's independent development of Fuji's board and diode arrangement. This is not true. Figure 10 is a true and correct excerpt from Scott's November 2016 beam spacing and angles summary[7] showing the assumptions used in the calculations of beam spacing for a LiDAR sensor designed to be mounted on a vehicle traveling at 30 mph.

[redacted]

Figure 6

[6] A true and correct copy of this document was previously attached as Exhibit A to my previous declaration. This document was also introduced and designated by Waymo as Exhibit 58 during my April 18 deposition.

[7] A true and correct copy of this document was previously attached as Exhibit E to my prior declaration. This document was also introduced and designated by Waymo as Exhibit 56 during my April 18 deposition.

The document excerpted above clearly shows that we independently came up with the idea to use [redacted] and in two optical cavities [redacted] Scott created this document after the LiDAR team realized that 32 laser diodes would need to be distributed across [redacted] boards to provide sufficient spacing. I communicated this to Scott, who then calculated beam spacing and angles for Fuji using the assumptions of distributed 64 beams in two cavities with [redacted] boards per cavity, which is reflected in the above document.

14. As I mentioned in my earlier declaration, Fuji uses commercially available edge-emitting laser diodes. A known technique of mounting laser diodes onto PCBs is to die attach and wire bond the laser diodes [redacted] that are integrated into the PCBs. As I explained in my earlier declaration, the [redacted] transmit PCBs are mounted onto the transmit block using two dowel pins that go through the mounting holes in each PCB. I understand that Waymo alleges in its reply brief that Uber uses both dowel pins and fiducials to position laser diodes. This is incorrect. As I had stated in my earlier declaration and again at my deposition, the mounting holes and dowel pins in Fuji are not used as reference points from which we position the laser diodes on any of the [redacted] transmit boards.[8]

15. As I mentioned in my earlier declaration, Fuji uses commercially available laser diodes that emit light with a wavelength of approximately 905 nm. It is publicly well known that a fast axis collimating ("FAC") lens can be used to pre-collimate the light emitted from a laser diode in order to focus and redirect the light towards a transmit lens.[9] I understand that although Waymo has not raised any arguments in its opening or reply briefs about Uber's FAC lens, I also understand that Waymo's expert has discussed this commonly used component in his reply declaration. Figure 12.A illustrates a true and accurate 3-D rendering of the FAC lens used in Fuji. [redacted]. Figure 12.B illustrates a

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[8] *See* Haslim Dep. 64:24-65:10. A true and correct excerpt of this section of my declaration is attached as Exhibit B to this declaration.

[9] *See* Hamamatsu, *FAC Lens (Fast-Axis Collimating Lens) J10919 Series*, *available at* https://www.hamamatsu.com/resources/pdf/etd/J10919_TOTH1005E.pdf.

true and accurate Zemax simulation of the beam output from Fuji's FAC lens. As shown in Figure 12.B, the FAC lens pre-collimates the light emitted from the laser diode such that [redacted]

[redacted]	[redacted]
Figure 7.A	Figure 7.B

Beam Spacing in Fuji

16. I understand that in its reply brief, Waymo contends that there is no evidence to support the fact that Uber independently developed Fuji, and its transmit boards, based on the work Uber had started in late October 2016. As I discussed in my earlier declaration, the position and orientation of the laser diodes in Fuji is based on the custom beam spacing and angle summary provided by Scott Boehmke in November 2016, which I included as Exhibit E in my earlier declaration. This summary provided the required beam angles for a 64 channel LiDAR with two cavities and [redacted] boards per cavity, on a vehicle traveling at 30 mph, 35 mph, 40 mph, and 45 mph. As I had previously explained, the current Fuji design is based on the beam angles for a vehicle traveling up to approximately 35mph. My team imported the angles in this summary into Zemax, a commonly known ray tracing simulation software program, to determine the resultant emitting points of the laser diodes. This data was then exported into SolidWorks CAD software as the basis for the initial optical cavity designs and transmit PCB designs.[10]

17. Figure 8.A is a true and correct annotated excerpt of the initial Fuji beam angles, and the difference or "delta" between each angle, for what I had previously referred to in my

[10] True and correct CAD drawings of the optical cavity and transmit PCBs are disclosed as Figures 2A-B and 6A-F in my original declaration.

earlier declaration as the "medium-range cavity," which contains transmit boards A-C and has a tilt of negative 12 degrees. Figure 8.B is a true and correct annotated excerpt of the initial Fuji beam angles, and the deltas between each angle, for what I had previously referred to in my earlier declaration as the "long-range cavity" that had no tilt. As shown in the color annotations in Figures 13.A and 13.B, the 32 channels in each cavity are distributed in a pattern such that one in every [redacted] channels is on the same PCB ([redacted]

[redacted]	
Figure 8.A	Figure 8.B

Below is a chart comparing the initial beam angles for the "medium-range" cavity provided by Scott in his November 2016 document (illustrated above in annotated Figure 13.A) with the current angular orientation of the diodes in transmit boards [redacted] previously provided in Exhibit B of my earlier declaration. Referring to transmit boards [redacted] the theta represents the downwards angular orientation of the diodes relative to the central axis through the transmit board. Because

there is an additional downwards tilt of 12 degrees in the "medium-ranged" cavity containing transmit boards [redacted] the theta for transmit boards [redacted] must also be adjusted by 12 degrees. For example, [redacted]. As the chart below confirms, there is no more than a 0.06 degree difference between initial Fuji beam angles in the November 16 document provided by Scott and the beam angles in the transmit boards in Fuji's "medium-range" cavity.

[redacted]

18. Below is a chart comparing the initial beam angles for the "long-range" cavity provided by Scott in his November 2016 document (illustrated above in annotated Figure 13.B) with the angular orientation of the diodes in transmit boards [redacted] previously provided in Exhibit E of my earlier declaration. Referring to transmit boards [redacted], the theta represents the angular orientation of the diodes relative to the central axis through the transmit board. Originally, Scott had provided diode angles which contemplated overlapping one beam in the long-range cavity with one beam in the medium-range cavity to compensate for any gaps in beam spacing that might arise due to manufacturing tolerances. I, however, believed that we could control the manufacturing tolerances such that we would not have to overlap beams (and effectively waste an entire channel), and accordingly shifted his proposed beam spacing. As the shown in the chart below, there is a consistent 0.18 to 0.24 degree shift between Scott's initial proposed beam angles and the beam angles in the transmit boards in Fuji's "long-range" cavity.

[redacted]

Comparison between Spider and Fuji

19. Below is a comparison of design specifications of the proposed Spider design and the Fuji device.

	Spider	**Fuji**
Type of Laser	Fiber lasers	Direct diode lasers
# of Channels	64	64
# of Cavities	8	2
# of transmit PCBs per cavity	None	[redacted]
# & Type of Transmit and Receive Lens	Total: 16 lenses total Per cavity: 2 lens that both transmit and receive	Total: 4 Per cavity: 1 lens for transmit and 1 lens for receive[11]
Pre-collimation Lens (i.e. FAC lens)	None	64 FAC lenses, one per diode
# & Type of Mirrors	One flat mirror with a hole	None
Weight	75 kg (approximately 165 lbs)	Maximum of 20 kg (approximately 44 lbs)
Beams or Points per second	3.2 million	1.5 million

Inspection of Spider Components

20. On Friday, April 14, 2017 and Monday, April 17, 2017, I oversaw the collection of existing components associated with the abandoned Spider project for Waymo's inspection on Wednesday, April 19, 2017. Esther Kim Chang of Morrison Foerster and Aaron Bergstrom of Uber assisted in this process.

[11] Not including the field flattening lens in the receive compartment within a cavity.

21. The majority of the mechanical components associated with the Spider project were located in a storage locker on the ground floor of Otto's former offices at 737 Harrison Street.

22. Eight fiber lasers and connected fiber optic splitters as well as electrical components associated with the Spider project were located under a tarp in the basement of 737 Harrison Street.

23. One optical cavity for testing purposes associated with the Spider project was located in a plastic bin near the storage locker on the ground floor of Otto's former offices at 737 Harrison Street.

I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct. Executed this on 28th day of April, 2017, in San Francisco, California.

James Haslim